This report was prepared with the support of HCFA Office of Research under Cooperative Agreement #18-C-98526/1-02 to the Health Policy Research Consortium - Cooperative Research Center. The HPRC is composed of Brandeis University, Boston University, The Center for Health Economics Research, and Urban Institute. Administrative offices are located at the Heller School, Brandeis University, Waltham, Massachusetts 02254.

CHAPTER NINE

THE ROLE OF PHYSICIAN PRACTICE PATTERNS IN WITHIN-DRG COST VARIATION

December 19, 1985

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9.0 THE ROLE OF PHYSICIAN PRACTICE PATTERNS IN WITHIN-DRG COST VARIATION

9.1 Introduction

Variation in hospital costs within DRG has typically been attributed to unmeasured severity differences. The fact that absolute levels of resource utilization vary across hospitals and across areas, however, suggests that at least part of this cost variation may be attributed to idiosyncratic practice pattern differences. The purpose of this chapter is to attempt to decompose cost variation into those patterns attributable to patient severity and those due to differences in the way physicians treat patients.

The underlying source of cost differences is absolutely critical to formulating new policy. If they are the result of genuine casemix differences, their higher costs may be justified on medical grounds alone. If, on the other hand, they are the result of systematic differences in practice styles that contribute little or nothing to ultimate patient outcomes, no adjustment may be warranted. These "style" differences could manifest themselves in greater service intensity or in simply keeping the patient in longer. Of course, the least expensive treatment is not necessarily the most appropriate, and more services may yield better care for some patients. The clinical optimum probably lies somewhere between the extremes.

This analysis is obviously critically dependent on our ability to measure within-DRG severity. We have taken three approaches to controlling for severity within DRG: (1) selection of DRG clusters; (2) inclusion of Disease Staging; and (3) the use of other patient characteristics. The use of DRG clusters is more fully described below, but briefly a DRG cluster represents all DRGs within which a patient with a given clinical condition could fall. This enables us to control for differential surgical utilization across areas and for differences in choice of surgical procedure.

9.2 Methods

9.2.1 Data Bases

The primary data base for this analysis was the pooled A-B claims files used to study physician DRGs (Mitchell, 1985). Briefly, hospital episodes were constructed from 1982 Medicare hospital and physician claims in four

states: Michigan, New Jersey, North Carolina, and Washington. These states had been chosen to represent each of the major geographic regions. Hospital admissions were classified into DRGs using the Grouper software, and physician (Part B) bills were then merged on at the patient stay level. These represent all physician services provided during the hospital stay.

Part A charges were transformed to reasonable costs using each hospital's Medicare Cost Report (MCR). Individual hospital descriptors were available from the MCRs and from AHA facility survey data.

9.2.2 Rationale and Description of Four DRG Clusters

The medical conditions for this analysis are four groups of related DRGs or "DRG clusters" (DRGCs). DRGCs merge together DRGs that were previously separated on the basis of age, comorbidity or complications, death, and major surgical procedure. This process yields pools of patients with identical or clinically closely-related diagnostic codes who may receive different types of services in different states (e.g., surgical versus medical treatment for the same disease). DRGCs protect against a biased selection of cases because of regional variation in the capability or willingness to perform certain operations. For example, patients with an angina diagnostic code appear in medical DRG 140, "Angina Pectoris," if they do not receive a cardiac catheterization, but are classified in DRG 125 if they do. If angina patients in one state are far more likely to receive a catheterization, sole focus on DRG 140 would understate the interarea differences in procedure mix. Only by combining DRGs can these practice pattern differences be appreciated. DRGCs also transcend the problem of differential coding of complications and comorbidities in different areas by including cases with and without complications. However, DRGCs do not control for regional epidemiologic variations, differences in admission threshholds, or differences in quality of care.

A number of factors guided selection of the four DRGCs. First, each must represent an important Medicare problem, translating into a large number of cases in the data base. Second, the set of four DRGCs must

reflect a range of service needs which could highlight differences in practice styles in different institutional settings, depending on

- whether patients could be cared for in a range of hospital types, large/small, teaching/nonteaching;
- whether patients could be treated medically or surgically;
- whether there is considerable physician discretion or controversy in choice of therapeutic approach;
- whether admissions are elective, permitting referrals for complex cases, or emergent;
- whether multiple layers of expensive technologies are potentially involved; and
- whether varying disease severity could influence choice of services and setting care.

Incorporating such considerations should increase the generalizability of the results to all DRGs.

Table 9-1 lists the four clusters, their component DRGs, and the sample sizes. The DRGCs, the specific factors influencing their selection, and the individual DRGs are described below:

<u>Cerebrovascular Disease Cluster (DRGs 5, 14, 15, 16, 17)</u>

Cerebrovascular disease (CVD) strikes hundreds of thousands of American elderly every year, and one out of six persons eventually die of its most serious manifestation, stroke. The clinical presentation is highly variable. CVD patients are treated in virtually every hospital setting. Since the symptoms of stroke often arise fairly suddenly over the course of a few hours, many patients are likely to first seek care at their local emergency facility.

Treatment of CVD is largely medical. Considerable controversy remains about the appropriate role of surgery (DRG 5), leaving room for important variations in its pattern of use. Surgery is generally reserved for elective prophylaxis -- prevention of eventual stroke -- in patients who appear at risk. Some physicians, however, recommend surgery on a semi-emergent basis to halt an "evolving" stroke. The surgery is fairly

TABLE 9-1

SAMPLE SIZES BY DRG CLUSTER BY STATE

DRG	Description	Number of Admissions: Michigan	New Jersey	North Carolina	Washington	Total
	<u>Cerebrovascular Disease Cluster</u>	16,528	15,720	11,351	6,092	49,691
5	Extracranial Vascular Procedures	1,030	802	602	981	3,415
14	Specific Cerebrovascular Disorders Except TIA	8,177	8,179	6,774	3,306	26,436
15	Transient Ischemic Attacks	5,552	5,587	2,760	1,487	15,386
16	Nonspecific Cerebrovascular Disorders w C.C.	271	285	0	156	712
17	Nonspecific Cerebrovacular Disorders w/o C.C.	1,498	867	1,215	162	3,742
	<u>Pneumonia Cluster</u>	7,960	6,571	6,696	3,368	24,595
79	Respiratory Infections + Inflammation Age >69 and/or C.C.	473	398	493	416	1,780
80	Respiratory Infections + Inflammation Age 18-69 w/o C.C.	86	93	147	23	349
81	Respiratory Infections + Inflammation Age 0-17	2	40	0	2	44
89	Simple Pneumonia + Pleurisy Age >69 and/or C.C.	6,089	4,756	4,672	2,702	18,219
90	Simple Pneumonia + Pleurisy Age 18-69	1,273	838	1,384	216	3,711
91	Simple Pneumonia + Pleurisy Age 0-17	37	446	0	9	492
	<u>Coronary Artery Disease Cluster</u>	20,883	15,670	15,877	6,586	59,061
106	Coronary Bypass With Cardiac Cath	257	143	413	637	1,450
107	Coronary Bypass w/o Cardiac Cath	686	224	161	453	1,524
125	Circulatory Disorders Exc AMI, With Card Cath w/o Complex Diag	2,121	1,747	1,530	873	6,271
132	Atherosclerosis Age >69 and/or C.C.	6,367	2,351	5,703	922	15,343
133	Atherosclerosis Age <70 w/o C.C.	1,456	610	2,116	77	4,259
140	Angina Pectoris	7,893	9,410	4,311	2,509	24,126
143	Chest Pain	2,103	1,185	1,643	1,115	6,046
	<u>Prostate Disease Cluster</u>	7,806	5,688	4,907	3,101	21,502
306	Prostatectomy Age >69 and/or C.C.	911	487	134	247	1,779
307	Prostatectomy Age <70 w/o C.C.	307	133	55	48	543
336	Transurethral Prostatectomy Age >69 and/or C.C.	3,499	2,844	2,457	1,988	10,788
337	Transurethral Prostatectomy Age <70 w/o C.C.	1,218	944	888	430	3,480
346	Malignancy, Male Reproductive System, Age >69 and/or C.C.	1,015	623	771	291	2,700
347	Malignancy, Male Reproductive System, Age <70 w/o C.C.	192	105	124	21	442
348	Benign Prostatic Hypertrophy Age >69 and/or C.C.	505	419	346	66	1,336
349	Benign Prostatic Hypertrophy Age <70 w/o C.C.	159	133	132	10	434

<u>Source</u>: Medicare Part A and Part B claims, 1982.

delicate, and is therefore more likely to be undertaken in more sophisticated hospital settings. In addition, surgical patients generally require pre-operative evaluation with angiography; the institution would therefore need this specialized radiologic capability. The evaluation of medical CVD patients can also be technology intensive, with several layers of technologies pursued sequentially.

Coronary Artery Disease Cluster (DRGs 106, 107, 125, 132, 133, 140, 143)

Coronary artery disease (CAD) is the most common cause of death in the United States, and with over 59,000 cases, it is also the largest DRGC in our sample. CAD cases are clearly treated in all different types of hospitals, but the technologic options are more numerous, varied, and expensive than in the other three DRGCs. CAD may be treated either medically or surgically, and there is still considerable variability in use of the surgical option.

This DRGC groups together those DRGs in which the majority of patients have coronary artery disease. It excludes patients medically treated for acute myocardial infarctions although most AMIs are caused by CAD. Issues of diagnostic semantics are particularly important in this DRGC. The definition of DRGs 106 and 107 is straightforward: these CAD patients receive surgical treatment, with or without concomitant cardiac catheterization. DRG 125 pertains to CAD patients who receive catheterization without surgery. DRGs 132 and 133 group patients with ICD-9-CM codes denoting the pathologic process of coronary atherosclerosis. DRG 140 includes patients with a clinical diagnosis of angina pectoris, generally precipitated by CAD. DRG 143 contains patients with the symptomatic diagnosis of chest pain. This chest pain group is potentially clinically very heterogeneous. Chest pain can be a manifestation of many diseases, including respiratory, abdominal, musculoskeletal, and even dermatologic processes. Yet, the DRG system groups all non-specific chest pain ICD-9-CM codes under the circulatory system disorder MDC, presuming that the pain is of cardiac origin; most cardiac chest pain is caused by CAD. Therefore, DRG 143 was included in this DRGC.

Pneumonia Cluster (DRGs 79, 80, 81, 89, 90, 91).

Pneumonia is a common disease of the elderly, both as a primary process and as a complication of underlying diseases also common in older persons, such as cancer and stroke. Treatment of pneumonia is generally medical, which is why this DRGC does not include a surgical DRG. Compared to other diseases in our sample (e.g., coronary artery disease), work-up and therapy of pneumonia itself is also less technology-intensive. The major focus here is on variability in hospital days themselves, particular ICU days.

The six DRGs which comprise this DRGC all pertain to infections or inflammation of the lung. DRGs 79, 80, and 81 incorporate conditions that are generally clinically more serious and for which the infective or causative agent is clearly identified. DRGs 89, 90 and 91 include a number of specific diagnoses of generally less serious nature (e.g., pneumococcal pneumonia), but they also serve as catch-all categories for all other pneumonias for which the exact etiology is unspecified. Failure to specify the precise etiology could stem from a number of circumstances, ranging from inadequacies of diagnostic technologies (despite aggressive efforts, it is sometimes simply impossible to precisely pinpoint the cause of a pneumonia) to sloppiness of reporting diagnostic results. Therefore, this DRGC covers all possibilities by including respiratory infections, inflammation, and pneumonias regardless of whether the exact cause is specified.

Prostatic Disease Cluster (DRGs 306, 307, 336, 337, 346-349)

Prostatic disease is an extremely common condition among older men, with its most common manifestation being benign prostatic hypertrophy (BPH). Prostatic malignancy is also frequent. However, clinically it is sometimes difficult to differentiate benign from malignant disease until a procedure is performed and prostatic tissue is microscopically examined. Also, treatment of early cancers may be similar to that for symptomatic benign disease (i.e., transurethral resection of the prostate, or TURP). Because of these clinical vagaries, this DRGC groups together both prostate cancer and benign prostatic disease.

The accepted treatment modality for both BPH and early cancer is the surgical TURP. Although TURP is considered a major procedure, it does not require the intensive support network needed for surgeries such as open-heart procedures. Virtually all TURPs are performed electively.

The four surgical DRGs in the DRGC reflect an interesting artifact of the Major Diagnostic Categories (MDCs) upon which DRGs are based. DRGs 306 and 307, "Prostatectomy," fall into MDC 11, "Diseases and Disorders of the Kidney and Urinary Tract." DRGs 306 and 307 contain more radical prostate surgery, but also encompass TURPs. (In fact, in all four states, over three-quarters of patients in DRGs 306 and 307 received TURPs.) However, DRGs 336 and 337, which are actually defined by the "TURP" procedure, fall into MDC 12, "Diseases of the Male Reproductive System." Thus, if a TURP patient has an ICD-9-CM diagnosis referable to the kidney and urinary tract (e.g., urinary obstruction, hematuria, dysuria), he is placed in DRGs 306 or 307, while if he has a male reproductive system ICD-9-CM diagnosis (e.g., prostate cancer, benign prostatic hypertrophy), he falls into DRGs 336 or 337.

9.2.3 Disease Staging as a Control for Within-DRG Case Mix

The Disease Staging method classifies patients into disease categories, and then assigns a level of severity, ranging from 1 (minimal severity) to 4 (death). This model results in nearly 400 disease categories each of which contains four distinct levels of severity. The basis of these categories-stages does not allow for comparisons of severity across disease categories but only within groups. Thus, according to Staging, patients in Bacterial Pneumonia Disease Category Stage 2 are more severely ill than those in Stage 1 of that Disease Category, but may be less severely ill than those in Stage 1 of the Tuberculosis Disease Category.

Unlike DRGs, which classify patients based on the principal (i.e. first-listed) diagnosis, Disease Staging can identify a single disease entity defined by two ICD-9 codes, and discern related and unrelated comorbid conditions. It does this by considering the relationship among the combinations of input diagnosis codes, which is the most likely underlying condition leading to the admission. For a more complete discussion of the staging methodology, see Calore (1985).

In an attempt to capture as many different dimensions of patient characteristics as possible, dummies based on results of the Disease Staging method were included in the multivariate analysis along with the DRGs

themselves, patient age, and death. The purpose of their inclusion was to further control for variation in resource use due to severity or case mix differences. The Disease Staging method may serve as a means of identifying the relatively few cases within a DRG that are generally unlike the majority of cases. For our purposes, it is more important that the cases within categories share clinical characteristics that result in similar resource use than that the patients in a higher stage of that disease really represent a sicker group. The reader should be cautioned that our results should not be interpreted as a test of the Staging approach because we have adapted it for our specific research purpose. The dummy variables themselves are shown in Table 9-2.

9.2.4 The Cost and Utilization Variates

Three adjusted hospital cost variates are calculated and presented in the descriptive comparisons:

(1) Medicare Part A inpatient costs per admission (ATOT);

(2) Part A plus all Part B radiology, anesthesiology, pathology, and ECG costs per admission referred to as adjusted or modified Part A costs (MATOT); and

(3) All Part A and B costs incurred during the admission (ABTOT).

A limitation of the Part A-only bills for comparative analysis is the systematic difference in A/B billing practices across hospitals. This is a particular problem with teaching hospitals that employ radiologists, anesthesiolgists, pathologists, and other hospital-based physicians (e.g., cardiologists). Using A-only bills that include these salaries in teaching institutions will arbitrarily overstate the teaching/non-teaching cost difference. By including the associated B bills, the bias is greatly reduced, if not eliminated.

Hospital charges from individual Part A claims were converted to costs using each hospital's Medicare Cost Report for fiscal year 1981. (All cost report data were inflated to represent December 1982 dollars, taking into account differing fiscal year end dates.) Routine and special care per diems and departmental cost to charge ratios were calculated using Medicare cost-finding principles. Post-stepdown figures were used, so that

TABLE 9-2

VARIABLE DEFINITIONS

Triaging Variables		
LNIRBEDS	=	Log (1 + IRBED), where IRBED = number of interns and residents per hospital bed.
LNTBEDS	=	Natural log of TBEDS, where TBED = total number of hospital beds, including special care beds.
LNDIV	=	Natural log of DIV, where DIV = proportion of 24 AHA services a hospital provides.
PCTADM2	=	Percent of total admissions to the hospital treated by internists.
PCTADM 3	=	Percent of total admissions to the hospital treated by other medical specialists.
PCTADM 4	=	Percent of total admissions to the hospital treated by general surgeons.
PCTADM 5	=	Percent of total admissions to the hospital treated by other surgical specialties.
PCTADM 6	=	Percent of total admissions to the hospital treated by other specialists.
SPEC	=	1 if attending physician is a designated specialist (actual list of specialty dummies varies by cluster)
Procedure Variables (all clusters)		
B_NOS8	=	Total number of consults per admission.
ICUCARE	=	1 if any ICU days for that admission.
SECMD	=	1 if that admission saw a second attending physician.
Prostate Cluster Procedures		
CYSTO	=	1 if cystourethroscopy performed.
NEEDLEBX	=	1 if needle biopsy performed.
UROG	=	1 if urography performed.
BONESC	=	1 if bone scan performed.
XRAY1	=	1 if spine or pelvis x-ray performed.
XRAY2	=	1 if abdomen x-ray performed.

TABLE 9-2 (cont.)

VARIABLE DEFINITIONS

CYSTOMET = 1 if cystometrogram performed.

ULTRASND = 1 if ultrasound performed.

Cerebrovascular Cluster Procedures

ANGI = 1 if cerebro angiography performed.

SCAN = 1 if radionuclide brain scan performed.

EEG = 1 if EEG performed.

LP = 1 if lumbar puncture performed.

CAT = 1 if CAT scan performed.

SKUL = 1 if x-ray skull performed.

AORT = 1 if thoracic aortography performed.

Coronary Artery Disease Cluster Procedures

ECHOCARD = 1 if echocardiography performed.

UPGASTRO = 1 if upper gastro series performed.

DOPPLER = 1 if doppler performed.

RADIOCD = 1 if radionuclide cardiac scan performed.

ABDXRAY = 1 if abdomen x-ray performed.

XTOL TEST = 1 if exercise tolerance test performed.

ANGIO = 1 if coronary angiography performed.

TEMPPACE = 1 if temporary pacemaker placement performed.

BP_MONIT = 1 if blood pressure monitoring performed.

GALLSTUD = 1 if gall bladder studies performed.

HOLTER = 1 if holter monitor performed.

FIBENDO = 1 if fiberoptic endoscopy performed.

TABLE 9-2 (cont.)

VARIABLE DEFINITIONS

Pneumonia Cluster Procedures

BRONCHO = 1 if bronchoscopy performed.

XRAYS = 1 if x-rays performed.

INTUB = 1 if intubation performed.

RADIONUC = 1 if radionuclide perfusion performed.

Wage Variables

LNWI = Natural log of 1981 PPS wage index.

U = 1 if hospital in urban area.

Casemix Variables

DRG Dummies = 1 if admission in a particular DRG (cluster-specific)

AGE = 1 if patient is 80 years or older (pneumonia and prostate cluster), or 85 years or older (CVD and CAD clusters)

DEATH = 1 if patient died in hospital

Other Cost Variables

LNLOS = Natural log of length of stay.

LNRDIEM = Natural log of hospital per diem.

Staging Dummies for Cerebrovascular Disease

CAR2 = Disease of the Carotid Artery Stage 2.

BAS 1 = Disease of the Basilar Artery stage 1.

ANEU1 = Aneurysm of Cerebral Vessels - Stage 1.

ANEU2 = Aneurysm of Cerebral Vessels Stage 2.

ANEU3 = Aneurysm of Cerebral Vessels Stage 3.

VERT1 = Disease of Vertebral Artery Stage 1.

VERT2 = Disease of Vertebral Artery Stage 2.

HEART = Coronary diseases, all stages

OTHDX = All other disease categories except disease of the carotid artery Stage 1.

TABLE 9-2 (cont.)

VARIABLE DEFINITIONS

Staging Dummies for Coronary Artery Disease

ENDOCARD = Infective Endocarditis, all stages.

MYOP1 = Cardiomyopathies, Stage 1.

MYOPOTH = Cardiomyopathies, Stages 2,3, and 4.

RHEU = Rheumatic Fever, all Stages.

ATHERO2 = Atherosclerosis of Coronary Arteries, Stage 2.

ATHERO3 = Atherosclerosis of Coronary Arteries Stage 3.

ATHERO4 = Atherosclerosis of Coronary Arteries, Stage 4.

AORTVOTH = Diseases of Aortic Valve, Stage 1.

AORTV1 = Diseases of aortic Valve, Stages 2, 3, 4

HYPERT = Essential Hypertension, all stages

CONDUCT = Conduction disorders, all stages.

OTHER CARD = Other cardiac disorders, all stages.

RESP = Bacterial pneumonia, and other respiratory disorders, all stages.

OTHDX = Other disease categories except atherosclerosis Stage 1.

Staging Dummies for Pneumonia

A12 = Anaerobic infections of lung, Stage 2.

BAC2 = Bacterial pneumonia, Stage 2.

BAC3 = Bacterial pneumonia, Stage 3.

TB2 = Tuberculosis, Stage 2.

ORES = Other respiratory disease categories, Stages 1,2 and 3.

BR2 = Bronchitis, Stage 2.

CA2 = Cancer of the Lung, Stage 2.

OTHDx = All other disease categories except bacterial pneumonia Stage 1.

TABLE 9-2 (cont.)

VARIABLE DEFINITIONS

Staging Dummies Prostatic Disease

BPH2	=	Benign Prostatic Hypertrophy, Stage 2.
BPH3	=	Benign Prostatic Hypertrophy, Stage 3.
BPH4	=	Benign Prostatic Hypertrophy, Stage 4.
CAP1	=	Carcinoma of the prostate, Stage 1.
CAP2	=	Carcinomia of the prostate, Stage 2.
CAP3	=	Carcinomia of the Prostate, Stage 3.
CAP4	=	Carcinoma of the Prostate, Stage 4.
OTHCA	=	Other cancers, Stages 1, 2 and 3.
OTHGU	=	Other genitourinary disorders, Stages 1, 2 and 3.
OTHDX	=	Other disease categories except BPH Stage 1.

costs included overhead departments. All costs were net of depreciation and interns' and residents' salaries. All per diems and cost-to-charge ratios were edited for extreme values. Excessively high or low numbers were cross-checked with the Medicare Cost Report data tape (sometimes even with the Part A intermediary), and corrected when appropriate.

In some cost analyses, the data have been deflated to account for interarea variation in input prices. No acceptable geographic hospital input price index currently exists,* and we were forced to use PPS's wage index, weighted by the percent of labor in total costs by urban-rural location. Given labor's very large input share (approximately 80 percent), errors in deflation are likely to be small, particularly compared to misinterpretations that arise from undeflated geographical comparisons. Because Washington claims were based on calendar year 1983, a one year temporal deflation was used to put costs in equivalent 1982 dollars. Finally, to simplify the multivariate analysis, only Modified A costs (MATOT) were analyzed,** although all three are descriptively compared.

Seven cost components are also analyzed: (1) total routine costs; (2) ICU costs; (3) operating room costs; (4) radiology costs (including B bills); (5) anesthesiology costs (including B bills); (6) laboratory costs; and (7) other miscellaneous costs (e.g., supplies, inhalation therapy). Each captures both the likelihood of incurring a specific cost, weighted by the average cost of positive users. Hence, some average department cost figures will seem very low because of a preponderance of non-use. For example, only 3 percent of urban Michigan pneumonia patients had any ICU costs, producing a $75 figure across all patients in the tracer. Among users, the average cost was 33 1/3 times greater.

Two general utilization statistics are also displayed:

(1) total length of stay (LOS); and

(2) percent with positive ICU use.

*HCFA has developed fairly detailed hospital input cost weights at the regional level, but these are used to generate a temporal inflation projection and not actual input price differences by region. See Freeland et al. (1981).

**Limited analysis using either Part A-only or ABTOT showed no material differences.

9.2.5 Specification of Physician Procedures

Each DRGC has its own set of procedures which is used in both the descriptive and econometric analyses (see Table 9-2). These procedures relate specifically to the work-up or treatment of the principal cluster condition. These "related procedure" lists were generated as follows. First, a list of expected related procedures was created based on *a priori* clinical expectations of the types of services received by patients with the tracer condition. Second, raw Part B claims data for each state yielded frequencies of claims by procedure code. These claims were examined not only for the services clinically expected, but additional high-volume services as well. Third, procedure codes for each state were reorganized to group together clinically similar codes and ensure consistency across the states. For example, New Jersey, Michigan, and Washington have three Head CT procedure codes while North Carolina has four; all four codes were grouped into a single procedure, "Head CT". The final list thus contains procedures related to the principal condition while closely-related procedures are bundled together and procedural coding made consistent across the four states.

9.2.6 Analytic Framework

Descriptive Analysis

Descriptive statistics are provided, comparing diagnostic mix, hospital costs, lengths of stay, and procedure mix across states. In order to hold casemix constant, all comparisons are made at the DRG level. In all descriptive tables, hospital costs have been deflated for geographic cost-of-living differences using the PPS wage index.

Multivariate Analysis

To statistically determine the cost contribution of practice styles above and beyond casemix/severity, stepwise regression analysis is used. The dependent variable is MATOT, undeflated (in natural logs). All

admissions within a tracer (including PPS outlier cases) are pooled across the four states. The general form of the equation is:

$$\ln(MATOT) = f(U;\ln(W);DRG;SEV;TRIAGE;PROC;STATE;LOS;RDIEM)$$

where ln(.) = natural logs, U = urban-rural dummy; W = HCFA's hospital wage index; DRG = a set of DRG dummies specific to the cluster; SEV = a vector of staging and other casemix dummies specific to the clusters; TRIAGE = vector of hospital and staff characteristics; PROC = vector of physician procedures provided to individual patients; STATE = three dummy variables for patients in the respective states (with North Carolina patients in the intercept); and LOS = length of stay; and RDIEM = the hospital's routine per diem.

The urban and wage index variables were stepped in first, in order to adjust for geographic cost-of-living differences, followed by the DRG dummies. The DRG dummies will tell us how much of the cost variation is explained by the DRG classification, and are also necessary since we are pooling across DRGs. They are, of course, a major casemix measure in their own right.

The next step included the Staging and other patient descriptors. Although Staging consists of a four-point ordinal scale, it is not comparable across disease entities. For analytic purposes, we constructed a set of dummy variables based on a combination of disease category and stage. Thus, for the prostate cluster, this would include such variables as prostate cancer stage 1, prostate cancer stage 2, hypertrophy stage 1, etc. These variables are shown in Table 9-2. Other patient level measures of severity included age (the age 70 split used for some DRGs may not be adequate for Medicare patients), and death.

Triaging variables are hospital and staff characteristics that may be related to patient severity. If more seriously ill patients are referred to certain hospitals or to certain physicians, this could explain within-DRG cost variation. Hospital characteristics include teaching status and service mix. Staff characteristics include specialty mix of the hospital staff and the specialty of the attending physician. These triaging variables are expected to have a major impact on total costs, not only because certain hospitals or specialists may treat sicker patients but also because they may order more (or more costly) diagnostic procedures.

The procedure vector includes the variables of key interest for this study, i.e., those discretionary treatment choices made by attending physicians which may drive up hospital costs. These include the decision to admit to the ICU, to involve other physicians in the care of the patient, and to order or perform diagnostic tests. Differential ancillary use was measured by a series of Part B procedure dummies. These variables are specific to the DRG cluster, but included, for example, whether or not a cystourethroscopy was performed, whether a CT scan was done, etc.

State dummy variables were stepped in to capture residual variation due to idiosyncratic locational practice patterns.

Finally, we included two other component cost variables: the length of stay for each admission; and the hospital's routine per diem. Including length of stay allowed us to separate the direct and indirect cost effects of procedures. The direct effect is the per day increase in the patient's real resource consumption. The indirect effect is the longer hospital stay that may result from scheduling and performing a particular test. Stepping in routine per diems represents an attempt to separate out per diem routine nursing intensity from other, unmeasured, daily utilization.

9.3 Variations in Casemix Across States

9.3.1 Differences in DRG Mix

The purpose of the DRGC construct was to capture differences in the performance of major surgery and in frequencies of older, comorbid cases across the four states that may indicate severity differences. Significant differences in the within-cluster mix of DRGs were observed in all four clusters, with consistent trends in the nature of these differences across the study states (see Table 9-3).

Washington displayed the highest proportion of cases receiving surgery in all three DRGCs containing surgical DRGs:

- In the CVD DRGC, 16.1 percent of Washington cases were operated on compared to 6.2 percent in Michigan, 5.3 percent in North Carolina, and 5.1 percent in New Jersey.
- In the prostatic disease DRGC, 87.5 percent of Washington cases received surgery, compared to 77.3 percent in New Jersey, 76.0 percent in Michigan, and 72.0 percent in North Carolina.
- In the CAD DRGC, 16.6 percent of Washington cases had coronary artery surgery, compared to 4.3 percent in Michigan, 3.1 percent in North Carolina, and 2.2 percent in New Jersey. In addition, 14.9 percent of Washington cases received cardiac catheterization, compared to 12.2 percent in New Jersey, 10.5 percent in Michigan, and 10.3 percent in North Carolina.

The differential surgery rates are particularly striking in the CVD and CAD DRGCs -- conditions in which the medical approach is the general mainstay of therapy.

In every case in which DRGs are split by age 70 and comorbidity, Washington patients fall disproportionately into the more complicated grouping when compared to the other three states. For example, the ratio of complicated to uncomplicated medical prostate cancer cases (DRG 346/DRG 347) is 13.4 in Washington, compared to 6.3 in North Carolina, 5.7 in New Jersey, and 5.2 in Michigan. Washington cases are also more likely to receive secondary diagnosis codes. For example, 20.7 percent of Washington DRG 89 pneumonia cases have a secondary diagnosis, compared to 7.2 percent in Michigan and 4.4 percent in New Jersey. (If cases do not have a secondary diagnosis, they are assigned to DRG 89 on the basis of age.)

TABLE 9-3

DRG MIX BY STATE

DRG	Description	Percent of Admissions: Michigan	New Jersey	North Carolina	Washington
	Cerebrovascular Disease Cluster				
5	Extracranial Vascular Procedures	6.2%	5.1%	5.3%	16.1%
14	Specific Cerebrovascular Disorders Except TIA	49.5	52.0	59.7	54.3
15	Transient Ischemic Attacks	33.6	35.5	24.3	24.4
16	Nonspecific Cerebrovascular Disorders w C.C.	1.6	1.8	0	2.6
17	Nonspecific Cerebrovacular Disorders w/o C.C.	9.1	5.5	10.7	2.7
	Pneumonia Cluster				
79	Respiratory Infections + Inflammation Age >69 and/or C.C.	5.9	6.1	7.4	12.3
80	Respiratory Infections + Inflammation Age 18-69 w/o C.C.	1.1	1.4	2.2	6.8
81	Respiratory Infections + Inflammation Age 0-17	0.0	0.6	0	0.6
89	Simple Pneumonia + Pleurisy Age >69 and/or C.C.	76.5	72.4	69.8	80.2
90	Simple Pneumonia + Pleurisy Age 18-69	16.0	12.8	20.7	6.4
91	Simple Pneumonia + Pleurisy Age 0-17	0.5	6.8	0	0.3
	Coronary Artery Disease Cluster				
106	Coronary Bypass With Cardiac Cath	1.2	0.9	2.6	9.7
107	Coronary Bypass w/o Cardiac Cath	3.3	1.4	1.0	6.9
125	Circulatory Disorders Exc AMI, With Card Cath w/o Complex Diag	10.2	11.2	9.6	13.3
132	Atherosclerosis Age >69 and/or C.C.	30.5	15.0	35.9	14.0
133	Atherosclerosis Age <70 w/o C.C.	7.0	3.9	13.3	1.2
140	Angina Pectoris	37.8	60.1	27.2	38.1
143	Chest Pain	10.1	7.6	10.4	17.0
	Prostate Disease Cluster				
306	Prostatectomy Age >69 and/or C.C.	11.7	8.5	2.7	8.0
307	Prostatectomy Age <70 w/o C.C.	3.9	2.3	1.1	1.5
336	Transurethral Prostatectomy Age >69 and/or C.C.	44.8	49.9	50.1	64.1
337	Transurethral Prostatectomy Age <70 w/o C.C.	15.6	16.6	18.1	13.9
346	Malignancy, Male Reproductive System, Age >69 and/or C.C.	13.0	10.9	15.7	9.4
347	Malignancy, Male Reproductive System, Age <70 w/o C.C.	2.5	1.8	2.5	0.7
348	Benign Prostatic Hypertrophy Age >69 and/or C.C.	6.5	7.4	7.0	2.1
349	Benign Prostatic Hypertrophy Age <70 w/o C.C.	2.0	2.6	2.8	0.3

[a]Columns sum to 100% within cluster.

Source: Medicare Part A and Part B claims, 1982.

Could the observed interstate differences in DRG mix be completely coding artifacts? The disproportionate number of Washington cases showing secondary diagnoses and appearing in the more complicated DRG pairs suggests Washington patients may actually be sicker than those in the other three states. But this could also reflect greater attention to coding detail in these 1983 Washington data (data in the other states are 1982). However, if the theory holds that the closer a state advances towards PPS the more thorough its hospitals coding efforts, then New Jersey, which began phasing in DRGs in 1980, should certainly have the most accurate diagnostic coding. Yet, compared to Washington cases, New Jersey cases appear systematically in the less severe DRGs.

Coding artifact is not an issue in the comparison of medical and surgical admissions. Washington cases are clearly more likely to receive surgery than their counterparts in the other three states. It would appear that Washington patients are not admitted for therapy until they are more severely ill, and if they are admitted, the objective is more likely to be surgical therapy.

This would seem to be confirmed by comparing admission rates across the four states (Table 9-4). Medicare patients in Washington are less likely to be hospitalized than those in other states, markedly so for patients with cerebrovascular and coronary artery disease. Even after adjusting for these lower admission rates, Washington surgeons are more than twice as likely to perform extracranial vascular procedures and coronary artery bypass grafts.

9.3.2 Interstate Differences in Diagnostic Mix Within DRGs

In an further effort to discover casemix differences across the four states, the pattern of principal ICD-9-CM diagnostic codes within DRGs was examined. The ICD-9-CM nomenclature and differences in coding patterns across the states confounded the analysis of the CAD and CVD clusters, preventing any clear conclusions regarding within-DRG severity. Interestingly, the mix of malignant to benign disease in the prostate disease cluster was fairly constant across states.

The pneumonia DRGC, however, reveals some clear evidence of differences in interstate disease mix (see Table 9-5). The more specified respiratory infection and inflammation DRG (DRG 79), displays some interesting differences. North Carolina has a very high percentage of cases with pulmonary tuberculosis (23 percent), particularly when compared to Washington (5 percent). The relative frequence of staphylococcal pneumonia

TABLE 9-4

HOSPITAL ADMISSION AND SURGERY RATES (per 1,000 Medicare Enrollees)

	Michigan	New Jersey	North Carolina	Washington
Cerebrovascular Disease				
Admissions	15.6	16.3	16.1	12.5
Extracranial Vascular Procedures	1.0	0.8	0.9	2.0
Coronary Artery Disease				
Admissions	19.7	16.2	22.5	13.5
Coronary Artery Bypass Grafts	0.9	0.4	0.8	2.2
Cardiac Catheterizations	2.2	2.0	2.8	3.1
Pneumonia				
Admissions	7.5	6.8	9.5	6.9
Prostate Disease[a]				
Admissions	7.4	5.9	7.0	6.3
Prostatectomies	5.6	4.6	5.0	5.5

Source: Medicare claims, 1982 and Statistical Abstract of the U.S., 1985.

[a]Rates based on all Medicare enrollees; data were not available for males only.

TABLE 9-5

COMMON ICD-9-CM DIAGNOSES WITHIN PNEUMONIA DISEASE CASES ACROSS THE FOUR STATES

DRG	Description	ICD-9-CM Name and Number	Percent of Cases[a]			
			Michigan	New Jersey	North Carolina	Washington
79	Respiratory Infections + Inflammation Age >69 and/or C.C.	Pulmonary Tuberculosis (01000 to 012800)	12%	17%	23%	5%
		Other bacterial pneumonia or pneumonia dua to Klebsiella pneumoniae (48200)	16	12	18	13
		Pneumonia due to Staphylococcus (48240)	8	7	3	18
		Aspiration pneumonia (50700)	43	39	39	40
89	Simple Pneumonia + Pleurisy Age >69 and/or C.C.	Pneumococcal pneumonia (48100)	7	6	4	11
		Pneumonia dua to Hemophilus Influenzae (48220)	1	1	0.4	6
		Bronchopneumonia, organism unspecified (48500)	7	10	10	6
		Pneumonia, organism unspecified (48600)	80	76	78	65
90	Simple Pneumonia + Pleurisy Age 18-69	Pneumonoccal pneumonia (48100)	6	6	4	15
		Pneumonia due to Hemophilus influenzae (48220)	0.5	1	0.4	7
		Bronchopneumonia, organism unspecified (48500)	9	10	9	7
		Pneumonia, organism unspecified (48600)	75	75	75	55

Source: Medicare Part A and Part B claims, 1982.

[a]Columns may not add to 100% due to residual ICD-9-CM diseases not shown.

shows the opposite: Washington 18 percent; and a low in North Carolina (2.3 percent). Tuberculosis and staphylococcal pneumonia are distinctly different clinical entities. Although both have highly variable clinical presentations, it may be safe to assert that elderly persons hospitalized for staphylococcal pneumonia are sicker than those with pulmonary tuberculosis. Thus, these Washington cases may be more severely ill than the North Carolina cases.

The proportion of aspiration pneumonias in DRG 79 is fairly constant across the four states, on the other hand. Aspiration pneumonias tend to occur in very elderly or debilitated patients who have difficulties protecting their airways during eating or sleeping. All four states appear to be equally burdened with these frail, quite sick patients.

Within DRGs 89 and 90, pneumonococcal pneumonia is more highly represented in Washington. The pneumococcus is a common cause of pneumonia in the elderly, especially in patients with other significant comorbidities such as cancer and alcoholism. The patient's initial presentation may appear extremely grave, but the response to treatment is generally rapid. Hemophilus influenzae pneumonia is also more common in the Washington population hospitalized under DRGs 89 and 90. In general, this disease is uncommon in adults, although alcoholics and patients with primary lung disease are at somewhat increased risk. Thus the two specific diagnoses emphasized in Washington appear to be associated with patients who are generally afflicted with other important diseases.

9.3.3 Staging the Four DRG Clusters

The Disease Staging results confirm many aspects of the DRG methodology and lend further support to the DRGC constructs. In DRG pairs split by age and presence of comorbidity, cases in the more "severe" DRG almost always fall more heavily into higher disease stages: staging agrees they are "sicker". The vast majority of cases in the prostate cluster are staged in two diseases: "Prostate Cancer", and "Benign Prostatic Hypertrophy". In the prostate cancer category, cases enter Stage 2 if they have a code indicating local tumor spread or moderate kidney damage; cases enter Stage 3 if they have a code indicating tumor metastases to other organs (e.g., bone, lung, liver) or severe kidney damage. In the benign prostatic hypertrophy (BPH) category, cases enter Stage 2 if they have a urinary tract infection or bladder dysfunction; Stage 3 requires more severe systemic or localized infection, renal failure, or shock.

The Staging results for prostatic disease follow a fairly consistent and clinically appropriate pattern (see Table 9-6). Cases in the older and complicated group of DRG pairs have higher stages and die more frequently than cases in the younger, uncomplicated groups. Medical prostate cancer cases die more frequently than medical BPH cases. As we found in other clusters, New Jersey has the highest overall death rates. For example, in the older, complicated medical prostate cancer group (DRG 346), New Jersey Stage 4 cases were 21.6 percent, compared to 15.5 percent in North Carolina, 14.0 percent in Michigan, and 13.9 percent in Washington. The lowest death rates varied among the other three states depending on the DRG and disease. Washington generally had the lowest fraction of cases in Stage 1, the least severe stage.

Within each of the DRGCs, however, coding practices vary widely across states in ways that may drastically affect the Staging assignments although there is no epidemological basis for the differences. Thus the prepondance of Stage 3 patients in a single state does not always mean that the patients are sicker but rather coding practices may be more or less precise. Reliance on the non-specified ICD-9 codes also compounds these findings, since the Staging algorithm arbitrarily allocates these frequently used codes to a stage within a disease in order to classify as many cases as possible. If the non-specific codes were not so widely used, their assignment to a given stage would only introduce noise within an otherwise homogenous category of patients. Unfortunately, this is not the case.

An example of this can be seen in DRG 140 (Table 9-7): 39.4 percent of North Carolina patients appear in Stage 3, compared to fewer than one percent in Michigan, New Jersey, and Washington. The answer to this puzzle lies in the staging algorithm and variability in coding styles across the states. The staging algorithm appropriately places patients with, "Angina Decubitus" (41300) (angina while this patient is at rest or lying down) into stage 3. But because Staging relies exclusively on 5-digit ICD-9-CM codes, it assigns cases with the general code 413, "Angina Pectoris", into stage 3 as well. In North Carolina, most of their cases received the more general code 413, compared with the very small number of cases with Code 41300 in the other three states. Clearly a coding style difference arbitrarily pushes North Carolina cases into Stage 3. Stage 2 assignment is driven

TABLE 9-6

STAGING ASSIGNMENTS WITHIN DRGS FOR PROSTATE DISEASE CLUSTER

DRG	Disease Name and Number	Stage	Percent of Cases[a] Michigan	New Jersey	North Carolina	Washington
336	Prostate Cancer	1	92.6	93.5	99.3	86.9
		2	1.2	1.1	0.0	1.3
		3	5.8	4.5	0.0	10.3
		4	0.3	0.8	0.7	1.5
	Benign Prostatic Hypertrophy	1	90.2	92.2	99.5	76.7
		2	8.6	6.8	0.0	20.0
		3	0.4	0.5	0.0	2.4
		4	0.4	0.6	0.5	0.9
337	Prostate Cancer	1	97.0	99.2	99.2	100.0
		2	0.6	0.0	0.0	0.0
		3	1.8	0.0	0.0	0.0
		4	0.6	0.8	0.8	0.0
	Benign Prostatic Hypertrophy	1	91.5	95.4	99.9	87.3
		2	8.0	4.3	0.0	12.4
		3	0.1	0.3	0.0	0.0
		4	0.4	0.1	0.1	0.3
346	Prostate Cancer	1	62.0	66.1	84.6	44.1
		2	1.3	0.0	0.0	2.1
		3	22.7	12.4	0.0	39.9
		4	14.0	21.6	15.5	13.9
347	Prostate Cancer	1	84.4	88.2	97.5	81.0
		2	0.6	0.0	0.0	0.0
		3	6.9	0.0	0.0	9.5
		4	8.1	11.8	2.5	9.5
348	Benign Prostatic Hypertrophy	1	86.9	90.4	98.6	73.9
		2	10.7	6.6	0.0	16.9
		3	1.4	0.7	0.0	9.2
		4	1.0	2.2	1.5	0.0
349	Benign Prostatic Hypertrophy	1	94.9	96.9	100.0	90.0
		2	3.9	3.2	0.0	10.0
		3	0.6	0.0	0.0	0.0
		4	0.6	0.0	0.0	0.0

Source: Medicare Part A and Part B claims, 1982.

[a]Percent of cases that fall into each stage of prostate cancer or benign prostatic hyptertrophy. This does not include the small number of other disease categories within the DRG.

TABLE 9-7

STAGING ASSIGNMENTS FOR ATHEROSCLEROSIS OF CORONARY ARTERY (815) DISEASE CATEGORY WITHIN DRGs ACROSS THE FOUR STATES

DRG	Description	Stage	Percent of Cases: Michigan	New Jersey	North Carolina	Washington
106	Coronary Bypass With Cardiac Cath	1	75.1	68.8	78.5	43.4
		2	13.1	20.3	10.6	32.5
		3	6.8	3.6	6.6	21.1
		4	5.1	7.3	4.3	2.9
107	Coronary Bypass w/o Cardiac Cath	1	86.4	86.7	78.1	66.1
		2	7.6	6.6	9.6	20.4
		3	3.9	0.5	7.5	11.1
		4	2.1	6.2	4.8	2.4
125	Circulatory Disorders Exc AMI, With Card Cath w/o Complex Diag	1	90.8	62.4	79.5	81.8
		2	4.6	26.4	10.6	10.9
		3	2.2	0.7	4.9	4.5
		4	2.4	10.5	5.0	2.9
132	Atherosclerosis Age >69 and/or C.C.	1	76.7	86.2	93.1	63.3
		2	18.3	7.0	0.5	31.8
		3	0.2	0.1	0.0	0.7
		4	4.8	6.8	6.4	4.2
133	Atherosclerosis Age <70 w/o C.C.	1	94.8	95.9	99.3	93.2
		2	2.1	1.2	0.4	4.1
		3	0.2	0.0	0.0	0.0
		4	3.0	2.8	0.3	2.7
140	Angina Pectoris	1	67.8	66.1	45.9	64.8
		2	31.2	32.4	14.1	33.1
		3	0.2	0.3	39.4	0.8
		4	0.9	1.1	0.7	1.3

Source: Medicare Part A and Part B claims, 1982.

mainly by Code 41110, "Intermediate Coronary Syndrome". (Synonyms for this term include unstable angina, impending myocardial infarction, and preinfarction angina). Only 616 cases in North Carolina receive this code, compared to 2,926 cases in New Jersey, 2,277 cases in Michigan, and 479 cases in Washington.

We have however found that in spite of the problems cited above, the Staging algorithm can be adapted to provide an additional measure of case mix. Rather than interpreting the sequential stages of a Disease Category as reflecting increasing levels of severity, we have found that Staging is particularly useful in identifying classes of patients within a DRG that have been "misclassified". By using all diagnostic information for a patient, rather than just the first diagnosis, and by looking at all diagnoses simultaneously, Staging can select groups of patients that are clinically different from others.

9.4 Descriptive Results by State

In this section, we present tabular results by state for selected DRGs within each cluster. Each cluster includes 5-8 different DRGs, and for ease of presentation, we show only a subset. The DRGs shown on each table were selected to represent a range of patient severity and service intensity. Both surgical and medical DRGs were included (where appropriate). In the discussions below, we will make cross-state comparisons for each DRG separately. The reader should keep in mind, however, that this tabular analysis can not adjust for inter-state differences in DRG mix. This is done in the multivariate analysis to follow. A brief synthesis is provided at the end of the section.

9.4.1 Variation in the Cost and Treatment of Cerebrovascular Disease

DRG 5: Extracranial Vascular Procedures: For the patients classified in DRG 5, the costs for hospital care vary substantially across states establishing patterns that repeat throughout the analysis. First, Michigan is by far the most costly, even after deflation, although New Jersey has the longest stays. (See Table 9-8). Second, while Washington has stays only half as long as those of New Jersey's, costs per case are almost as high. This suggests Washington physicians are able to shorten stays through more intensive services, with little net difference on overall hospital costs.

How do physician practice patterns vary among these states to account for this high cost variation? First, the number of consults is substantially higher in New Jersey than elsewhere, a pattern that repeats throughout all DRGs. Similarly, New Jersey patients are far more likely to have an additional physician billing regular hospital visits (see percent Second MD line).

A second aspect of practice differences is the propensity to admit patients to the ICU. The very low frequency of ICU utilization in Michigan occurs throughout all four clusters. Because these rates are implausibly low for many DRGs, particularly surgical ones, we are certain that these costs are actually included elsewhere in the hospital claim. One explanation, is that these patients remain postoperatively in the recovery room for extended periods. Submitted bills would report them as routine per diems plus an additional recovery room charge. Unfortunately, we can not separate recovery room from operating room charges in our analytic data base.

TABLE 9-8

VARIATION IN TREATMENT OF CEREBROVASCULAR DISEASE

DRG	5				14				15			
STATE	MI	NJ	NC	WA	MI	NJ	NC	WA	MI	NJ	NC	WA
Part A Cost ($)	$4,587	$3,789	$4,340	$3,398	$3,935	$3,478	$2,727	$3,323	$2,096	$1,813	$1,484	$1,255
Part A (Adj) Costs ($)	5,365	4,370	4,913	3,889	4,092	3,597	2,809	3,444	2,298	1,934	1,608	1,392
Part A and B Costs ($)	6,651	6,770	6,760	5,752	4,548	4,182	3,171	3,866	2,629	2,350	1,852	1,614
Length of Stay	12.5	14.4	12.5	7.5	16.0	18.9	16.1	12.6	9.1	11.0	7.8	5.1
No. of Consults	1.15	1.4	0.91	0.38	0.98	1.04	0.43	0.76	0.81	0.84	0.38	0.38
% in ICU	7.6	74.8	80.6	71.5	4.0	16.0	14.9	17.3	2.9	8.5	9.6	9.7
% with Specialist Attending	99.8	100.0	100.0	100.0	72.6	79.2	62.4	65.7	71.1	78.1	63.6	65.3
% with Second MD	61.8	86.7	64.1	45.3	23.5	46.9	26.0	49.9	16.3	33.4	17.4	28.4
% with Head CAT	13.8	22.7	35.2	10.1	23.9	34.0	36.4	45.2	17.6	26.8	27.5	24.6
% with X-ray skull	9.1	3.7	4.7	0.6	13.9	14.5	8.2	1.8	13.5	15.9	9.4	1.7
% with X-ray Cervical/Spine	1.7	4.2	1.7	1.9	3.0	3.3	2.1	1.7	5.3	6.0	2.9	2.6
% with Thoracic Aortography	40.3	15.9	20.6	8.3	3.5	0.5	1.0	0.5	14.7	2.6	4.3	4.7
% with Cerebro Angiography	48.1	33.7	65.7	33.2	4.4	1.9	3.4	3.7	16.3	5.5	11.2	18.3
% with Radionuclide Scan	5.9	5.6	5.6	0.3	17.5	19.0	10.1	2.3	21.1	22.8	12.3	2.2
% with Echocardiography	5.0	2.4	6.1	4.2	3.4	4.0	4.7	8.3	4.4	3.5	6.9	6.6
% with EEG	3.3	3.5	18.3	3.8	4.9	3.8	11.4	12.8	5.0	3.5	13.9	9.9
% with Lumbar Puncture	.7	.9	1.5	0.2	4.1	5.4	3.9	2.7	1.2	2.0	2.0	1.0
% Died	1.2	4.1	1.7	2.9	17.1	20.2	16.3	15.3	1.1	2.0	0.9	1.1

Source: Medicare Part A & Part B claims, 1982.

To further illustrate treatment differences across states, we have included the frequency of nine different physician procedures. Generally Michigan physicians appear to favor use of radiologic procedures ranging from skull x-rays to the more complicated thoracic aortography and cerebroangiography. Surprisingly, head CAT scans are not ordered as frequently in Michigan as they are elsewhere. Low rates of CAT scan use in Michigan persists across all DRGs within the CVD tracer. Physicians in New Jersey, on the other hand, order fewer of these complex services with the exception of CAT scans. However, costs of physician services account for 35 percent of the total costs of care for New Jersey patients compared with only 19 percent in Michigan, 27 percent in North Carolina and 32 percent in Washington. New Jersey physicians may be providing more services unrelated to the reason for admission during the hospital stay (i.e., procedures not listed on this table). The higher proportion of patients dying in New Jersey also suggests that these patients may have more complications than those in other states.

North Carolina physicians admit to the ICU more frequently than elsewhere and uncharacteristically order CAT scans most often (in one out of three cases). They also order cerebro-angiography far more than physicians in the other states.

DRG 14: Specific Cerebrovascular Disorders Except TIA: The patients in this DRG represent a variety of specific cerebrovascular conditions and the costs of care vary significantly by state. North Carolina is the least costly by far, while Michigan again is the most costly.

It is interesting to note that although North Carolina physicians admit patients as frequently to the ICU as elsewhere, they generally order fewer tests and procedures with the exception of head CAT scans and EEGs. In Washington, the short stays are clearly compensated for by selective increases in service intensity, i.e., high rates of head CAT scans and echocardiography. However, Washington physicians order far fewer radionuclide scans than elsewhere, using CAT scans as substitutes.

DRG 15: Transient Ischemic Attack: This DRG includes stroke patients who experienced a TIA, but have no permanent damage from the stroke. The costs of hospital treatment are highly correlated with length of stay and consultation rates. Generally, the comparison confirms the patterns discussed above. Michigan physicians order radiologic procedures more

frequently, while those in New Jersey and North Carolina include the head CAT scans more often. Again, EEGs are particularly popular in North Carolina. Stays in Washington for this DRG are so much shorter that they completely dominate any intensity effects, producing major cost savings.

9.4.2 Variation in Treatment of Coronary Artery Disease

DRG 106: Coronary Bypass Graft with Cardiac Catheterization: There is relatively little variation in total costs across states, especially once we add in all Part B services as well (see Table 9-9, line 3). Although costs for DRG 106 remain somewhat less in Washington, the differential is not nearly as large as we might have expected given Washington's exceedingly short stays. Adjusted Part A costs are 10-25 percent lower in Washington than in the other three states, but hospital stays are 25-70 percent shorter. Clearly, Washington patients must be receiving more intensive services during those short stays although its procedure mix shows little indication of it.

Consultation rates show a clear positive relationship with length of stay, a pattern that will be repeated for all DRGs. Again, the very low ICU rates for Michigan are not plausible for this DRG.

Included in Table 9-9 are twelve diagnostic and therapeutic procedures. The first eight are clearly related to coronary artery disease, while the last four would be part of a diagnostic work-up for chest pain. All services vary considerably in frequency across states. Michigan physicians are particularly likely to order cardiac radionuclide scans, implant temporary pacemakers, insert peripheral arterial lines or central venous catheters, and order abdominal x-rays. New Jersey physicians perform cerebrovascular blood flow studies like Dopplers at an extremely high rate, implant temporary pacemakers, and order Holter monitors. By contrast, North Carolina physicians order relatively few of these procedures, with the notable exception of Holter monitors. Of particular interest is the fact that they are far less likely to conduct angiography at the time of cardiac catheterization. (By definition, all patients in DRG 106 have been catheterized.) Washington physicians are not as service-intensive as we might expect, although they are more apt to insert peripheral arterial lines or central venous catheters, and to order abdominal x-rays.

In spite of their greater intensity, mortality rates in Michigan and New Jersey are 2-3 times as high as in the other two states. This strongly suggests that their patients are more seriously ill, which may (at least partially) explain their higher per case costs.

TABLE 9-9

VARIATION IN TREATMENT OF CORONARY ARTERY DISEASE

DRG	106				125				132				140			
STATE	MI	NJ	NC	WA	MI	NJ	NC	WA	MI	NJ	NC	WA	MI	NJ	NC	WA
Part A Costs ($)	$14,336	$12,063	$13,338	$11,404	$2,746	$3,172	$3,871	$2,388	$2,510	$2,339	$2,138	$1,877	$2,103	$1,938	$1,772	$1,525
Part A (Adj) Costs ($)	15,434	13,122	14,120	12,273	3,125	3,291	4,050	2,526	2,626	2,408	2,212	1,965	2,209	1,991	1,838	1,596
Part A and B Costs ($)	19,616	19,519	18,967	17,176	3,899	4,261	4,980	3,337	2,934	2,833	2,488	2,182	2,471	2,368	2,061	1,788
Length of Stay	20.5	23.9	17.9	14.0	6.9	10.4	8.5	4.7	10.4	12.0	10.7	6.4	8.4	9.8	7.6	4.8
No. of Consults	1.54	2.30	0.96	0.66	0.54	0.74	0.56	0.35	0.51	0.62	0.23	0.24	0.40	0.42	0.15	0.21
% in ICU	34.2	94.4	83.8	96.9	12.2	39.2	25.8	33.8	13.0	29.6	34.7	42.8	20.7	49.2	50.7	65.6
% with Spec. Attending	99.2	100.0	99.5	100.0	93.7	94.7	96.7	96.5	73.8	76.0	62.8	66.3	74.6	85.3	67.0	71.3
% with Second Attending	75.5	91.6	78.2	87.8	11.9	24.5	21.3	25.6	11.0	26.2	15.1	26.7	9.9	18.7	14.0	26.7
% with Echocardiogram	5.8	3.5	9.2	7.4	6.2	7.9	19.6	8.7	2.6	4.5	4.1	5.9	4.7	4.2	4.4	4.1
% with Cerebrovascular Blood Flow Studies (Dopplers)	3.9	27.3	0.2	7.4	1.1	1.1	0.1	0.6	4.0	4.1	2.2	0.8	2.3	1.6	0.7	0.3
% with Cardiac Radionuclide Scans	17.9	14.7	14.8	10.2	9.8	12.3	14.3	3.2	4.8	6.2	3.5	2.7	6.3	8.5	4.5	1.6
% with Exercise Tolerance Test	3.5	4.2	5.8	1.9	4.3	2.8	14.0	2.5	0.8	1.2	2.4	2.1	1.9	1.6	5.4	2.0
% with Temporary Pacemaker	8.9	5.6	1.2	1.9	11.6	3.8	2.7	2.4	0.6	0.4	0.6	0.2	0.2	0.2	0.2	0.5
% with Peripheral Arterial Lines & Central Venous Catheters	24.9	4.9	6.8	15.4	3.6	4.3	2.5	1.0	0.6	0.4	0.5	0.5	0.3	0.2	0.0	0.2
% with Holter Monitor	5.1	30.8	14.5	0.8	1.5	3.4	13.4	1.7	3.0	3.6	5.7	1.3	5.0	3.6	5.1	0.1
% with Angiography	82.9	92.3	64.9	80.4	90.1	74.7	89.7	92.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% with Upper GI Series	3.5	2.8	3.4	0.9	4.3	4.5	9.9	2.7	8.7	10.4	9.8	4.3	10.4	10.6	11.5	4.7
% with Abdominal X-rays	12.1	8.4	7.3	17.1	6.5	10.5	8.7	9.8	9.2	10.4	8.1	5.0	6.4	5.6	5.8	4.2
% with Gallbladder Studies	1.2	3.5	1.2	0.2	1.1	3.0	4.2	0.1	2.5	5.1	3.6	0.5	3.6	5.6	5.4	0.7
% with Upper GI Endoscopy	2.7	0.7	0.5	0.6	1.1	0.8	1.0	0.8	1.3	1.5	0.8	0.1	1.3	1.0	1.4	0.7
% Died	7.4	9.1	5.1	4.2	2.9	10.3	4.3	4.0	6.0	7.5	6.4	5.9	0.9	1.1	0.6	2.2

Source: Medicare Part A & Part B claims, 1982.

DRG 125: Non-Complex Circulatory Disorders with Cardiac Catheterization: Again Washington is the least expensive and shortest stay state, but, in contrast to other DRGs, North Carolina is the most expensive. The reason for this apparently lies in the extensive use of virtually all services listed on Table 9-9. North Carolina physicians appear to be performing extensive diagnostic work-ups on many of the patients admitted to this DRG. Michigan physicians are less likely to call in a second attending physician, but tend to insert more temporary pacemakers. New Jersey attendings are far less likely to perform angiography when catheterizing patients, but are apt to order radionuclide scans. Again New Jersey patients would appear to be more seriously ill, as evidenced by their higher death rates. Finally, DRG 125 admissions do not appear very service-intensive in Washington; there may be a limit to what you can do in 4.6 days!

DRG 132: Atherosclerosis Age 70+ and/or Complicating Conditions: Like DRG 106, we observe the familiar patterns of higher hospital costs in Michigan and in New Jersey and the lowest in Washington. Lengths of stay and consultation rates show a similar positive relationship with each other and with total costs. In spite of higher costs, Michigan physicians appear to adopt a relatively low intensity, individualistic, practice style. They are far less likely to admit a patient to the ICU or call in a second physician. By contrast, New Jersey attendings are twice as likely to call in a second physician, and more likely to order radionuclide scans, and upper GI and abdominal studies. North Carolina physicians more frequently order Holter monitors, upper GI x-rays, and gallbladder studies. Except for a slightly higher use of echocardiography, Washington physicians do not use many diagnostic procedures. They are, however, far more likely than their colleagues in other states to call in a second attending and to admit atherosclerosis patients to the ICU.

DRG 140: Angina Pectoris: Hospital costs, lengths of stay, and consultation rates show the same pattern with highest levels for all three in Michigan and New Jersey followed by North Carolina, and then Washington. Similarly, Michigan physicians are least likely to call in a second attending and admit to the ICU, while Washington physicians are most likely to do both. Washington attendings are less apt to order diagnostic work-ups for chest pain (the last four procedures), which undoubtedly explains part of their low LOS for the DRG.

9.4.3 Variation in Costs and Treatment of Pneumonia

DRG 79: Respiratory Infections and Inflammations Age 70+ and/or Complicating Conditions: As seen in Table 9-10, the two long stay states, New Jersey (19.6 days) and Michigan (17.4 days), have substantially higher hospital costs than the other states.

For cases in DRG 79, the principal discretionary service is admission to the ICU. Yet, an interesting anomaly appears in that Michigan is the most expensive state by far, but admits substantially fewer patients to the ICU. Only 5.3 percent are admitted to the ICU in Michigan while ICU admissions account for 13 to 20 percent in the other states. Thus, treatment costs in Michigan appear unrelated to whether the patient is in a special care unit unless these costs are included elsewhere for medical patients, as we suspect they were for surgical patients (which seems less likely).

Consultation rates are highest in the two long stay states, but the use of a second attending is greatest in the shortest stay state (Washington). The frequency of both a bronchoscopy and additional chest x-rays is positively related to length of stay. New Jersey physicians order a bronchoscopy as a routine part of the diagnostic work up nearly twice as often as in North Carolina or Washington, a trend that appears throughout the DRGC. Radionuclide pulmonary perfusion scans are ordered less often in Washington than elsewhere. Emergent intubation, on the other hand, is more frequent in the two expensive, long stay states (Michigan and New Jersey), and a significantly higher proportion of patients die in these states. This suggests that these patients may indeed be sicker.

DRG 80: Respiratory Infections and Inflammations Age Less than 70 and/or Without Complicating Conditions: The profile of hospital costs for the younger uncomplicated patients shows that their treatment is somewhat less intense than for those in DRG 79, although the length of stay distribution looks quite similar for all but Washington, where there are very few cases.

Practice patterns are generally similar to those in DRG 79, with very high rates of bronchoscopy in New Jersey.

DRG 89: Pneumonia Age 70+ and/or Complicating Conditions: The costs of hospital care for patients in this DRG also show a lot of variation across states. Although the lengths of stay are nearly the same in Michigan and

TABLE 9-10

VARIATION IN TREATMENT OF PNEUMONIA

DRG	79				80				89				90			
STATE	MI	NJ	NC	WA	MI	NJ	NC	WA	MI	NJ	NC	WA	MI	NJ	NC	WA
Part A Costs ($)	$6,251	$4,898	$3,889	$4,086	$4,981	$4,284	$3,234	$5,341	$3,422	$3,067	$2,527	$2,666	$3,075	$2,486	$2,372	$2,005
Part A (Adj) Costs ($)	6,418	5,003	3,977	4,182	5,106	4,373	3,327	5,462	3,522	3,138	2,592	2,743	3,181	2,557	2,440	2,078
Part A and B Costs ($)	6,980	5,741	4,414	4,634	5,521	5,083	3,744	6,097	3,857	3,625	2,875	3,035	3,508	3,009	2,708	2,305
Length of Stay	17.4	19.6	15.8	12.1	15.2	19.4	13.7	14.5	12.4	14.5	12.1	8.7	10.8	11.8	10.3	6.6
No. of Consults	1.0	1.04	0.42	0.50	0.93	1.03	0.51	0.48	0.51	0.64	0.21	0.27	0.52	0.62	0.19	0.15
No. of Chest X-ray	3.6	4.3	3.2	2.8	2.4	2.7	2.9	3.1	2.2	2.5	2.2	2.0	1.9	2.1	2.1	1.7
% in ICU	5.3	20.1	13.8	15.9	4.7	11.8	15.0	13.0	2.8	13.0	10.2	12.6	3.1	12.9	9.3	7.4
% Specialist Attending	78.4	85.2	65.5	64.7	69.8	88.2	67.3	69.6	61.2	77.3	53.1	58.0	60.7	79.4	56.4	58.8
% Second Attending	23.7	35.7	20.5	40.4	17.4	34.4	24.5	30.4	12.0	28.1	13.9	31.2	11.1	26.4	13.4	22.2
% with Emergent Intubation	3.8	4.3	1.4	2.4	4.7	3.2	2.0	4.3	1.4	1.6	0.9	1.5	0.9	0.6	1.1	0.5
% with Bronchoscopy	10.1	13.8	7.5	6.7	14.0	19.4	8.2	8.7	3.9	6.5	3.0	4.5	7.0	8.5	5.3	4.2
% with Radionuclida Pulmonary Perfusion Scans	3.4	3.3	1.6	3.1	1.2	1.1	4.1	8.7	3.8	5.6	3.6	2.8	5.0	8.1	4.0	6.0
% Died	22.8	25.9	15.2	16.8	16.3	11.8	2.7	4.3	13.1	15.2	12.6	9.1	5.9	4.3	1.0	4.2

Source: Medicare Part A and Part B claims, 1982.

North Carolina, average Michigan costs per care are $1000 more. Comparing the utilization of physician services across these states doesn't explain this difference. Either per diems are substantially higher in Michigan or more services unrelated to the pneumonia (and not shown on this table) are provided during the hospital stay. New Jersey patients stay in the hospital two days longer but the costs are still less than those in Michigan. Washington, with an average stay at least 50 percent shorter than the other states, is still more expensive than is North Carolina. Their short stays are offset by more intense use of services during the stay.

Physicians in Michigan and New Jersey are more likely to order a consult for pneumonia patients, but it is Washington where there is the greatest likelihood of having a second attending physician. Generally, New Jersey physicians order more of everything--but their use of bronchoscopy stands out in all DRGs.

DRG 90: Pneumonia Age Less-than-70 or Without Complicating Conditions: The younger and noncomplicated pneumonia patients share a very similar pattern of hospital costs with the patients in the older, complicated group. It is uniformly less expensive to treat these patients largely because the average stay is two days shorter. Washington physicians are less likely to admit patients to the ICU in this DRG, while in the other states, the likelihood of being admitted to the ICU is similar to that for DRG 89, despite evidence that the patients in DRG 90 are less severely ill (i.e., lower death rates).

9.4.4 Variation in Treatment of Prostate Disease

DRG 306: Prostatectomy (associated with diseases of the kidney and urinary tract): Hospital costs are remarkably similar across the four states (within $500), although lengths of stay and consultation rates exhibit a familiar pattern with lowest levels in Washington and highest levels in New Jersey (see Table 9-11). Michigan urologists only call in a second attending in one out of three cases and almost never admit to the ICU. They are, however, far more likely to perform cystourethroscopies and cystometrograms than are their colleagues in the other three states. New Jersey urologists, on the other hand, almost always call in a second physician, are more prone to admit to the ICU, and favor urography and cystourethroscopy. North Carolina urologists, however, are by far the most

TABLE 9-11

VARIATION IN TREATMENT OF PROSTATE DISEASE

DRG	306				336				346				348			
STATE	MI	NJ	NC	WA	MI	NJ	NC	WA	MI	NJ	NC	WA	MI	NJ	NC	WA
Part A Costs ($)	$3,245	$3,272	$3,524	$2,919	$2,962	$2,578	$2,370	$1,999	$2,950	$2,343	$2,141	$2,185	$1,985	$1,578	$1,602	$1,316
Part A (Adj) Costs ($)	3,535	3,551	3,780	3,193	3,225	2,822	2,576	2,223	3,107	2,469	2,258	2,307	2,131	1,690	1,740	1,415
Part A & B Costs ($)	4,535	5,047	4,999	4,424	4,200	4,144	3,693	3,282	3,493	2,945	2,575	2,595	2,512	2,122	2,026	1,691
Length of Stay	11.7	15.0	12.5	9.5	10.6	12.0	10.4	6.9	11.9	12.7	11.3	8.7	8.3	8.2	7.5	5.2
No. of Consults	0.84	1.09	0.65	0.37	0.77	0.90	0.48	0.21	0.83	0.79	0.48	0.40	0.78	0.84	0.60	0.32
% in ICU	1.5	9.0	12.7	3.6	0.9	6.0	7.5	3.5	1.1	3.9	2.2	4.8	0.6	3.6	4.9	7.6
% with Spec. Attending	100.0	100.0	100.0	98.8	100.0	100.0	100.0	97.9	80.2	87.2	79.2	78.4	83.4	89.0	75.7	66.7
% with Second Attending	36.9	86.7	49.3	47.0	39.0	84.1	39.6	30.4	17.3	34.3	17.9	27.5	17.8	34.8	22.5	21.2
% with Prostate Needle Biopsy	1.9	2.1	0.7	1.6	4.7	2.0	2.5	1.5	9.3	6.9	6.9	6.2	16.4	7.6	15.6	13.6
% with Urography	37.3	48.7	46.3	27.9	29.8	27.9	45.2	14.4	13.2	12.7	20.1	7.6	41.8	27.7	48.3	28.8
% with Radionuclide Bone Scan	7.6	11.9	20.1	5.7	12.1	13.4	14.5	5.5	21.8	25.5	29.1	12.7	12.7	4.3	6.6	3.0
% with Cystourethroscopy	44.9	32.4	15.7	17.4	39.9	15.0	13.9	5.2	17.1	19.1	15.3	9.3	61.4	54.2	47.7	30.3
% with Cystometrogram	7.0	3.5	3.0	0.0	6.4	1.6	2.9	0.2	1.2	0.5	0.5	0.0	9.3	2.6	3.5	0.0
% with Spine X-rays	6.3	5.7	6.0	2.4	5.9	5.2	3.9	1.9	21.6	14.7	13.4	13.7	5.0	3.8	6.4	6.1
% with Abdominal Ultrasound	6.4	8.2	12.7	4.5	4.2	5.2	5.5	2.2	6.4	4.5	6.0	6.5	5.9	4.3	8.1	4.5
% with Abdominal X-rays	6.5	12.9	10.4	9.3	5.1	5.7	8.1	3.1	11.0	10.1	11.8	8.6	7.9	6.4	11.6	4.5
% Died	1.1	1.4	1.5	0.8	0.5	0.9	0.6	0.2	15.4	22.2	15.4	15.1	1.2	2.6	1.4	0.0

Source: Medicare Part A & Part B claims, 1982.

service-intensive, with high levels of ICU use, urography, bone scans, abdominal ultra-sound, and spinal and abdominal x-rays (i.e., flat plates or KUBs). The latter procedures are generally performed when looking for metastases, and a cancer diagnosis is 2-3 times more prevalent in North Carolina for this DRG than in the other three states.

Utilization levels are low for all services in Washington. Surgeons here keep their patients in the hospital a shorter period of time and do less to them while they are there.

DRG 336: Transurethral Prostatectomy (associated with disorders of the male reproductive system): Total costs, lengths of stay, and consultation rates exhibit their familiar pattern: high levels in Michigan and New Jersey and low levels in Washington. Relative use of diagnostic services across states is much the same here as it was for DRG 306. This is not surprising, as patients in both DRGs are being treated by the same urologists. However, while North Carolina surgeons order tests for metastases at levels as high or higher than those of their colleagues, here the prevalence of prostate cancer does not vary across states.

DRG 346: Malignancy of the Male Reproductive System: Total hospital costs vary considerably across state with per case costs 50 percent higher in Michigan than in Washington. Again, inter-state patterns of service use are similar to those observed for the surgical DRGs in this tracer. Michigan attendings rarely use the ICU, but frequently perform cystourethroscopies and order spine x-rays. New Jersey physicians are more apt to call in a second attending, admit to the ICU, and also frequently perform cystourethroscopies. Mortality rates in New Jersey are 45-50 percent higher than in the other three states which may partially explain their somewhat longer stays. North Carolina attendings favor urography and bone scans, while those in Washington order all services at levels at or below those of their colleagues.

DRG 348: Benign Prostatic Hypertrophy: Again, we observe similar patterns for costs, lengths of stay, consultation rates, ICU use, and the propensity to call in a second attending. Michigan physicians favor cystourethroscopies and cystometrograms just as they do for patients in other DRGs. North Carolina attendings perform relatively more urography and more work-ups for possible cancer, even though no patients in this DRG received a cancer diagnosis!

9.4.5 Synthesis

Although the preceding tables encompassed a (sometimes bewildering) array of data, we can identify distinct, practice styles for the four states. These styles are not cluster-specific but pervade all of the DRGs analyzed.

Michigan distinguishes itself as by far the most costly of our four states, even after adjusting for geographic input price differences. Costs appear to be high due to both long stays and high levels of ancillary use. Michigan physicians (or the large number of consults they bring in) are particularly prone to order x-rays and to perform diagnostic surgical procedures like bronchoscopy and cystourethroscopy. Unlike their colleagues in other states, Michigan physicians do not relinquish primary control of their patients; they are less likely to call in a second attending.

New Jersey physicians keep their patients in the hospital longer than anywhere else; and involve many more other physicians in their care (both as consultants and as second attendings). Hospital costs remain somewhat lower than those of Michigan, however, because some ancillary services are performed less frequently. Nevertheless, New Jersey physicians are clearly intensive users of other physicians, using them both as substitutes (e.g., as a second attending) and as complements (e.g. x-ray interpretation).

North Carolina physicians keep their patients hospitalized about as long as do those in Michigan, but achieve far lower costs due to reduced service intensity. They operate fairly independently with relatively little direct use of other physicians (as consultants or as second attendings). Nevertheless, North Carolina physicians do have a penchant for particular procedures, such as EEGs, CAT scans, and certain kinds of x-rays.

Washington physicians produce the least expensive admissions of any of our four states. They do so primarily by discharging their patients far faster than anywhere else. Washington hospital costs are not nearly as low as might be expected given their short lengths of stay because of greater service intensity. Washington physicians tend to team up with a second attending to provide a wide array of services over a short period of time. Other physicians are infrequently used as consultants, however.

9.5 Regression Analysis of Total Cost Variation

9.5.1 Introduction

The regression analysis begins with an explanation of the variation in total costs (Part A plus Part B radiology, anesthesiology, and pathology). Section 9.6.2 summarizes the incremental effects on the explained variation by controlling for additional factors or covariates. This is followed by several subsections highlighting the effects of the attending physician's specialty, consults and other attending physicians, and procedure mix.

9.5.2 Incremental Changes in Explanatory Power

For each cluster, stepwise regression equations were estimated based on the hierarchical framework described above in the Methods section. The resulting R-squares associated with each step are shown in Table 9-12. These R-squares cannot be interpreted as the unique variation explained by each vector of variables. Rather, they represent the incremental, or added, explanatory power due to each vector, given that all preceding variable have been held constant. Had any of the steps been reversed, the results could be quite different. (How different will be shown explicitly in Chapter 10.)

The first step shown in Table 9-12 generated R-squares ranging from 0.095 to 0.328. Included in this step are dummy variable for DRGs, the PPS wage index, and an urban/rural dummy. The reason for this large differential in explanatory power across clusters lies in the DRGs themselves. The pneumonia cluster includes only medical DRGs and previous research has shown medical DRGs as a group to be poor predictors of hospital costs (Mitchell, 1985). By contrast, the other three clusters include a mix of medical and surgical DRGs with sharply different costs. The much higher R-square for the CAD cluster is due to the especially large cost differences between those DRG admissions involving bypass grafts and all others. The standardized regression coefficients associated with DRGs 106 and 107 (both including bypass grafts) are 0.37 and 0.35 at this step, for example, compared with 0.18 for DRG 125 (cardiac catheterization only) and 0.07 for DRG 140 (angina).

TABLE 9-12

INCREMENTAL R-SQUARES IN HOSPITAL COST REGRESSIONS

Step		Coronary Artery Disease	Cerebrovascular Disease	Pneumonia	Prostate Disease
1	DRG Urban Wage Index	0.328	0.199	0.095	0.172
2	Severity	0.335	0.204	0.105	0.193
3	Hospital Characteristics	0.354	0.233	0.134	0.213
4	Attending MD Specialty	0.356	0.234	0.138	--
5	Consults & Other Attendings	0.411	0.317	0.277	0.344
6	Procedures	0.520	0.360	0.336	0.402
7	States	0.544	0.379	0.354	0.413
8	Lengths of Stay	0.842	0.824	0.813	0.792
9	Routine Per Diems	0.863	0.839	0.833	0.834

Source: Medicare Part A and Part B claims for Michigan, New Jersey, North Carolina and Washington, 1982.

Although most of the variables in the severity vector (the second step) are statistically significant, their marginal contribution to explaining cost variation is small. Because of the very large number of observations, however, even small increments in explanatory power, as small as 0.5 percentage points, are statistically significant. Nevertheless, these changes are still so small as to not be particularly meaningful, only 0.5 to 2.1 percentage points.

Stepping in the vector of hospital characteristics generates a statistically significant increase in explanatory power for all four clusters, but only 2 to 3 percentage points. Most powerful among this set of variables, not surprisingly, is teaching status (measured by interns and residents per bed). At this step, only the dummy variables representing surgical DRGs are relatively more important in explaining hospital costs, as determined by the standardized regression coefficients.

The specialty of the attending physician in the next step adds surprisingly little to the model's explanatory power, although again the incremental R-squares are statistically significant for all three clusters.* Much of the attending specialty effect may have been captured previously with the vector of hospital characteristics that included the specialty mix of the hospital medical staff. Hospitals with a larger share of internists on staff are significantly more expensive in the treatment of coronary artery disease, for example, and this means that there will then be less residual variation for an internist-attending dummy to explain. It is also likely that choice of attending physician and choice of hospital are jointly determined. When a patient selects a specific attending, he is at the same selecting a member of a given hospital medical staff (although, to the extent that physicians are on staff at more than one hospital, this relationship is lessened somewhat.) Nevertheless, we were interested in this step to determine the marginal impact of attending physician specialty on costs, holding constant hospital size, teaching status, etc.

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*We were unable to include this step for the prostate disease cluster, as there was no variation in attending physician specialty for surgical DRGs; all were treated by urologists.

The involvement of other physicians in the care of the patient has a large and dramatic impact on explained hospital cost variation. This step includes only two variables: (1) the number of consultations; and (2) the presence or absence of a second attending physician. Yet, it raises the R-squares by 6-14 percentage points. Explained cost variation for the pneumonia cluster actually doubles. Given the large number of variables already held constant, these incremental R-squares are surprisingly large, both in absolute and in relative terms.

Of course, consults and second attendings may raise hospital costs because these additional physicians order and perform more procedures.* We will examine this directly in a later section. In any case, stepping in the procedures themselves (Step 6 of Table 9-12) results in another large increase in explanatory power: 4-11 percentage points depending on cluster. This, of course, is not too surprising since we would expect what is done to the patient to affect total hospital costs. What is important, however, is that use of these procedures varies substantially across states and that many of these procedures raise total costs far beyond what would be expected by their nominal costs alone. When abdominal x-rays are performed on CAD patients, for example, hospital costs are 26.4 percent higher than they would be in the absence of such x-rays, <u>ceteris</u> <u>paribus</u>. Given a cluster-wide mean of $1,959, this implies an added cost of $517, far more than the actual cost of performing and interpreting the x-rays. In section 9.4.5 below, we will see why this is the case.

Finally, dummy variables were stepped in to determine what residual cost variation could be explained by the state in which the physician practices. Although the incremental R-squares are quite small (1-2 percentage points), the fact that they are all significant suggests that there are cross-state differences in treatment styles not captured by our list of included procedures, consultation rates, etc. Treatment of all four clusters still costs substantially more in Michigan than in any of the other three states

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*The regression coefficients associated with these two variables are positive and significant in all four cluster equations.

ceteris paribus. Even holding constant the more frequent use of temporary pacemakers, peripheral arterial lines, etc. by Michigan physicians, for example, treatment of CAD patients is 31 percent more expensive than in North Carolina, 33 percent more than in New Jersey, and 46 percent more than in Washington.

After stepping in this wide array of variables, almost two-thirds of the cost variation in cerebrovascular disease and pneumonia, and approximately one-half of that in coronary artery and prostate disease, remain unexplained. Residual variation might be accounted for by inter-hospital price differences, the performance of other procedures not included in the equations, or by differences in length of stay, not reflected in the included variables. More to the point, previous research has documented dramatic, unaccounted for, length of stay differences across both large and small geographic areas (Chassin, 1983). Including length of stay directly into the cost regressions as an eighth step raises the R-squares from those shown in the last row of Table 9-12 to the 0.79-0.84 range. It is possible that length of stay is capturing unmeasured severity differences across patients, but it is equally likely that it is capturing idiosyncratic physician practice styles.

Finally, the hospital's routine per diem cost was stepped into the equation. These per diems were calculated based on Medicare reasonable cost-finding principles and are a constant dollar number for all admissions within a given hospital. Only an additional 2-4 percentage points of total cost variation could be attributed to these inter-hospital price differences, however.

9.5.3 Hospital Cost Effects of the Attending Physician's Specialty

Because of differences in training and orientation, different specialties may treat similar patients more or less intensively. Table 9-13 presents the percent increase (or decrease) in hospital costs associated with a given specialty as attending physician. The percent changes in the first column are based on the regression coefficients associated with the specialty dummies in the fourth step, i.e., holding DRG mix, severity and hospital characteristics constant but before stepping in consultants, other attendings, and procedures.* Thus, thoracic surgeons

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*Actual regression coefficients have been exponentiated to put the effects in arithmetic terms.

TABLE 9-13

HOSPITAL COST EFFECTS OF ATTENDING MD SPECIALTY[a]

	Total (1)	Adjusted for Consults & Other Attendings (2)	Adjusted for (2) and Procedures Performed (3)
<u>Coronary Artery Disease</u>[b]			
Cardiologist	0.5% (n.s.)	9.3%	3.8%
Thoracic Surgeon	-10.0	-10.7	-1.9 (n.s.)
Multi-Specialty Group	-3.8 (n.s.)	3.2 (n.s.)	0.1 (n.s.)
Internist	4.6	10.1	5.5
GP/FP	1.1 (n.s.)	1.9 (n.s.)	0.9 (n.s.)
Other Specialist	11.8	8.3	7.0
<u>Cerebrovascular Disease</u>[c]			
Cardiologist	6.2	5.4	0.9 (n.s)
Neurologist	2.8 (n.s.)	-0.9 (n.s.)	-7.1
Internist	5.2	5.5	3.7
Other Specialist	10.9	8.2	3.6
<u>Pneumonia</u>[c]			
Pulmonary Disease Specialist	30.2	24.5	9.9
Internist	12.0	14.5	11.1
Cardiologist	14.8	14.5	6.8
Other Medical Specialist	14.0	7.5	3.5 (n.s.)
Other Specialist	6.5	5.2	4.1

[a]Percent changes in total hospital costs holding DRG, severity, wages, hospital and physician characteristics, and location constant.

[b]Reference group consists of general surgeons.

[c]Reference group consists of GPs and FPs.

<u>Source</u>: Medicare Part A and Part B claims for Michigan, New Jersey, North Carolina and Washington, 1982.

lower the costs of CAD treatment by 10.0 percent compared with general surgeons, _ceteris paribus_, while internists raise costs by 4.6 percent. Percent changes in columns (2) and (3) are based on regression coefficients from steps 5 and 6, respectively.

Some percent changes in col. (1) are quite large, especially given the small incremental R-square associated with the inclusion of the specialty dummies. A pneumonia patient with a pulmonary disease specialist as attending, for example, will incur hospital costs 30.2 percent higher than an otherwise similar patient treated by a GP. Because pulmonary disease specialists are so infrequent (admitting only 2.1% of all pneumonia patients), however, they do not contribute much to the overall cost variation.

There is surprisingly little change in the effect of attending-physician specialty on costs once we adjust for consults and the presence of a second attending (col. 2). This suggests that specialty effects are relatively independent of the involvement of other physicians. A notable exception are cardiologists and internists who apparently rarely use other physicians in their treatment of coronary artery disease; these specialists add even more to total hospital costs after we adjust for consults and second attendings.

Most of the cost impact of the attending physician's specialty appears to result from the procedures he or she performs and not the use of complementary physicians. As shown in col. 3, the percent changes in hospital costs diminish considerably in absolute size once we step in procedures. Take cardiologists, for example, who produce more expensive hospital stays for all three tracers shown. Based on the percent changes in col. 2, a cardiologist raises the cost of CAD treatment by $182 compared to GPs, cerebrovascular disease treatment by $119, and the cost of a pneumonia admission by $337, _ceteris paribus_. However, once we adjust for the echocardiographies, radionuclide scans, angiographies, and other procedures they perform, the added cost of a cardiologist over a GP is only $74 for CAD patients, (an insignificant) $20 for cerebrovascular admissions, and $158 for pneumonia cases. Neurologists are the sole exception to the general trend of more expensive admissions for specialists; apparently because of their short hospital stays, their hospital costs are significantly less than those of GPs once we adjust for the expensive diagnostic procedures they perform.

9.5.4 Cost Effects of Consults and Additional Attendings

Earlier, we saw that the involvement of other physicians in a patient's care led to a dramatic increase in explained cost variation. What are the actual dollar implications of calling in a consult or a second attending? How much of the added costs are due to the procedures that these other physicians order? Table 9-14 presents the percent increase in hospital costs associated with each consultation received and with the presence of a second attending. The percent changes in the first column are based on the regression coefficients associated with those two variables in the fifth step, i.e., holding constant DRG mix, wages, severity, hospital characteristics, and physician specialty, but not procedures. Thus, every consultant on a CAD case raises costs by 21.2 percent; when a second attending is brought in, costs rise by 23.0 percent. Percent changes in col. (2) are based on regression coefficients from step 6, while those in col. (3) are based on the final step when length of stay was added to the equations.

The dollar impacts of additional physicians on a case are very large. Returning to the coronary artery disease example, the percent changes in col. (1) imply that each consult adds $415 (in $1982) to the average CAD hospital bill, and the second attending another $451, relative to a cluster-wide mean of $1,959. The dollar impacts for the other clusters are similarly large.

Some of these added costs are in fact due to the procedures performed by these other physicians, as we can see from col (2); the percent changes diminish in size once the cluster-specific set of procedures are stepped in. Nevertheless, the involvement of other physicians still remains quite costly. Even after adjusting for procedures like radionuclide scans and angiography, a consultant raises CAD hospital costs by $334 on average, and a second attending by $292.

Why are other physicians so costly, if not because of the procedures they perform? (Remember that our measure of hospital costs does not include their own fees which appear as Part B bills.) Apparently, it is because their involvement keeps patients in the hospital longer. Once we adjust for length of stay (col. 3, Table 9-14), the consult and second attending effects shrink markedly, although all remain statistically significant. Each consultant on a CAD case now "only" adds $49 to the hospital bill, and

TABLE 9-14

EFFECTS OF CONSULTS AND ADDITIONAL ATTENDINGS ON TOTAL HOSPITAL COSTS

	Total (1)	Adjusted for Procedures (2)	Adjusted for Procedures and LOS (3)
Coronary Artery Disease			
Consults	21.2%	17.4%	2.5%
Second Attending	23.0	14.9	2.7
Cerebrovascular Disease			
Consults	18.9	16.6	2.3
Second Attending	25.8	20.9	2.8
Pneumonia			
Consults	36.1	29.6	6.2
Second Attending	25.3	20.0	4.3
Prostate Disease			
Consults	27.2	21.5	4.4
Second Attending	13.5	12.1	-0.6 (n.s.)

[a]Percent changes in total hospital costs holding DRG, severity, wages, hospital and physician characteristics, and location constant.

[b]State also held constant here.

Source: Medicare Part A and Part B claims for Michigan, New Jersey, North Carolina and Washington, 1982.

a second attending $53. The difference between these dollar amounts and those based on the percent changes in col. (2) can be interpreted as the added per diem costs incurred by CAD patients when additional physicians are brought in on their case. From length of stay equations not presented here, we know that a consultant and a second attending will each lengthen CAD hospital stays by 1.5 days, adding several hundred dollars in routine costs alone to the bill.

Why do consults and second attendings result in longer hospital stays? There may be delays after first requesting a specialist, the consultation itself is time-consuming, and there may be delays in waiting for additional test results. Alternatively, the causality may be reversed, and consultants are called in because patients are sicker and a second medical opinion is therefore solicited, extending stays on severity grounds. Although certainly true in some cases, we believe our assumption of causality is correct for several reasons. First, we have held DRG mix and several other measures of patient severity constant. Second, we have also adjusted for triaging to specialist physicians and specialized hospital facilities as well as for the procedures performed during the admission. (Adjustments for triaging include hospital and attending physician characteristics, such as teaching status, specialty mix, etc.) Third, the inter-state variation in consultation rates and in the propensity to use a second attending are so large that a severity-driven model of causality is implausible. It is hard to accept the argument that patients in a consultant-intensive state like New Jersey are materially sicker than elsehwere, over-and-above that controlled for with our covariates.

9.5.5 Impact of Procedures on Total Hospital Costs

Earlier we saw that stepping in procedures greatly increased our ability to explain hospital costs. This was not surprising, as we would expect the services performed during the stay to add to total costs. What was surprising, however, was that the percent changes associated with these procedures implied cost effects far larger in value than the actual costs of the procedures themselves (see col. 1, Table 9-15). When abdominal x-rays are conducted during a CAD admission, for example, total hospital costs rise by $517. The second column presents the percent changes associated with each procedure, holding length of stay constant.

TABLE 9-15

UNADJUSTED AND ADJUSTED COST EFFECTS OF MEDICAL PROCEDURES[a]

	Unadjusted	Adjusted for LOS
Cerebrovascular Disease		
CT scan, head	9.4%	5.0%
Skull X-rays	2.5	1.0 (n.s.)
Thoracic Aortography	16.3	20.1
Cerebrocervical Angiography	15.3	26.1
Radionuclide Brain Scan	14.7	4.3
Echocardiography	8.3	3.9
EEG	5.1	1.9
Lumbar Puncture	18.3	9.2
Coronary Artery Disease		
Echocardiography	15.2	5.1
Cerebrovascular Blood Flow Studies (Dopplers)	20.6	6.1
Radionuclide Cardiac Scans	36.5	13.2
Exercise Tolerance Test	-1.1 (n.s.)	-2.0
Catheterization with Angiography	-17.1	5.5
Temporary Pacemaker	21.0	18.9
Peripheral Arterial Lines and Central Venous Catheters	21.0	5.1
Holter Monitor	13.3	0.3 (n.s.)
Upper GI Series	15.2	2.4
Abdominal X-rays	26.4	8.4
Gallbladder Studies	-1.3 (n.s.)	1.3 (n.s.)
Upper GI Endoscopy	27.4	4.8
Pneumonia		
Bronchoscopy	32.9	10.8
Additional Chest X-rays	7.9	-1.5
Emergent Intubation	59.6	37.3
Radionuclide Pulmonary Perfusion Scans	12.5	10.3
Prostate Disease		
Cystourethroscopy	13.8	5.9
Prostate Needle Biopsy	1.9 (n.s.)	8.6
Urography	10.5	0.2 (n.s.)
Radionuclide Bone Scans	12.9	7.7
Spine X-rays	21.9	2.2
Abdominal X-rays	28.8	7.4
Cystometrogram	14.9	6.4
Abdominal Ultrasound	25.6	8.9

[a] Percent changes in total hospital costs holding all other factors constant (DRG, severity, wage index, location, hospital and physician characteristics).

Source: Medicare Part A and Part B claims for Michigan, New Jersey, North Carolina and Washington, 1982.

Once we adjust for length of stay, abdominal x-rays add "only" $165 (vs. $517) to the costs of CAD care, a dollar value more consistent with the actual costs of performing and interpreting the x-rays. CAD patients who receive abdominal x-rays stay longer in the hospital, which includes waiting for the x-rays to be scheduled and/or for the radiologist to read the films. In fact, longer stays is a major reason why procedures drive up hospital costs; once length of stay is held constant, the percent changes associated with virtually all of the procedures diminish in size, some markedly so.

The reverse is true, however, for three similar types of procedures: (1) thoracic aortography and (2) cerebrocervical angiography in the case of cerebrovascular disease patients, and (3) cardiac catheterization with angiography for CAD patients. Here, adjusting for length of stay actually increases their contribution to total hospital costs. Although all three procedures are quite costly, they are all associated with shorter hospital stays, possibly because they are scheduled prior to admission.

9.6 Impact of Within-DRG Severity on Total Hospital Costs

Earlier we saw that the variables in the severity vector (staging dummies, patient age and death) explained only a small amount of hospital cost variation, above and beyond DRGs. Nevertheless, these variables were generally always statistically significant, suggesting that they are capturing real casemix differences within DRG. Table 9-16 presents the percent increase (or decrease) in hospital costs associated with a particular clinical charateristic. The percent changes in the first column are based on the regression coefficients associated with the severity dummies in the second step, i.e., holding DRG mix, wage index, and urban location constant but before stepping in hospital characteristics, procedures, etc. The second column is based on step 7, holding all other variables except length of stay and per diems constant.

Based on the first column, neither stage 2 patient with benign prostatic hypertrophy (BPH) nor the rare BPH patient who dies (stage 4) are any more costly than their uncomplicated peers. (Stage 1 BPH patients are the omitted group.) Stage 3 patients with benign prostatic hypertrophy are very expensive, however, costing 41.8 percent more to treat.

Generally speaking, prostate cancer patients are more expensive to treat than stage 1 BPH. The total hospital costs of stage 1 prostatic cancer are 14.7 percent higher while those with metastatic disease (stages 2 and 3) are one-third more costly. Terminal prostate cancer patients (stage 4), on the other hand, are surprisingly inexpensive, only three-quarters of the cost of an uncomplicated BPH stay, suggesting that death must come quickly after admission.

The remaining three diagnostic variables represent a mix of disease categories and stages, and are difficult to interpret. There were insufficient number of any one disease category - stage combination to include separately.

Prostate disease patients aged 80 years and older are 10.5 percent more costly than their younger counterparts, suggesting that the 70+ age split in the prostate DRGs may not be appropriate. Patients with diagnoses other than cancer and BPH and who die are almost twice as expensive to treat. (The Staging algorithm assigns all prostate cancer and BPH deaths to stage 4 of their respective disease categories.) This small group of patients (3%) is probably very atypical.

As a rule, once we adjust for triaging variables and procedure mix, the magnitude of the percent changes are reduced (col. 2 in Table 9-16). Even still, stage 3 patients remain far more expensive to treat. The stage 3 BPH patient with complications such as bacteremia is 30 percent more costly than uncomplicated cases. Similarly, the Stage 3 prostate cancer patient with systematic metastases costs 20 percent more. If these cancer patients die in the hospital (Stage 4), however, they are still significantly less expensive to treat than any others in this cluster.

9.7 Summary

Some of the within-DRG hospital cost variation can be attributed to severity differences. Subgroups of patients with different clinical charateristics and higher or lower hospital costs were identified using the Disease Staging algorithm. However, these casemix variables contributed only modestly to overall explanatory power. Far more important were practice styles, the varying mix of services and procedures performed by physicians during the hospital admission. These included specialty consultations, additional attending physicians, and a wide range of surgical and radiological procedures.

TABLE 9-16

EFFECTS OF WITHIN-DRG SEVERITY ON HOSPITAL COSTS FOR PROSTATE DISEASE

	Unadjusted[a] (1)	Adjusted[b] (2)
Benign Prostatic Hypertrophy, Stage 2	1.9% (n.s.)	5.3%
Benign Prostatic Hypertrophy, Stage 3	41.8	30.4
Benign Prostatic Hypertrophy, Stage 4	8.2 (n.s.)	-4.0 (n.s.)
Prostate Cancer, Stage 1	14.7	6.1
Prostate Cancer, Stage 2	33.3	3.8 (n.s.)
Prostate Cancer, Stage 3	38.5	19.9
Prostate Cancer, Stage 4	-27.6	-18.4
Other Cancers	4.1 (n.s.)	6.9 (n.s.)
Other Genito-urinary Disorders	5.1	5.5
Other Diagnoses	2.9 (n.s.)	2.1 (n.s.)
Patient Age 80+	10.5	6.5
Died (other dx)	82.8	58.7

[a]Percent changes in total hospital costs, holding DRG mix, wage index, and urban location constant.

[b]Percent changes in total hospital costs, holding all covariates except length of stay and routine per diems constant.

<u>Source</u>: 1982 Medicare Part A and B claims.

Many procedures, like x-rays and operations, add to the total hospital bill, because some portion of their costs are incurred in the hospital setting. But a large part of their cost impact is indirect, i.e., increased costs resulting from longer hospital stays. Similarly, consultants and additional attendings, who have no Part A analog, nevertheless drive up hospital costs by keeping patients in the hospital longer. Time spent waiting for consultations and test results, scheduling queues, and other delays all probably contribute to these longer stays.

Of course, it is conceivable that the causality may be reversed: consultants and tests are ordered because patients are sicker and longer hospital stays are justified on severity grounds. Although certainly true in some cases, we believe our assumption of causality is correct for several reasons. First, we have held DRG mix and several other measures of patient severity constant. Second, we have also adjusted for triaging to specialist physicians and specialized hospital facilities as well as for the procedures performed during the admission. (Adjustments for triaging included hospital and attending physician charateristics, such as teaching status, specialty mix, etc.) Third, the inter-state variation in consultation rates and the propensity to order procedures are so large that a severity-driven model of causality is implausible. It is hard to accept the argument that patients in a service-intensive state like New Jersey are materially sicker than elsewhere, <u>over-and-above</u> that controlled for with our covariates.

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